DTU Library

Optimizing electrode shapes for ERT monitoring in permafrost areas

Tomaskovicova, Sonia; Ingeman-Nielsen, Thomas; Christiansen, Anders V.; Brandt, Inooraq; Dahlin, Torleif; Elberling, Bo

Published in:
Proceedings of the XI. International Conference on Permafrost

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Tomaskovicova, S., Ingeman-Nielsen, T., Christiansen, A. V., Brandt, I., Dahlin, T., & Elberling, B. (2016). Optimizing electrode shapes for ERT monitoring in permafrost areas. In *Proceedings of the XI. International Conference on Permafrost* (pp. 988-989)

Optimizing electrode shapes for ERT monitoring in permafrost areas

Sonia Tomaskovicova[1], Thomas Ingeman-Nielsen[1], Anders V. Christiansen[2], Inooraq Brandt[3], Torleif Dahlin[4], & Bo Elberling[5]

[1] *Technical University of Denmark, Denmark*
[2] *Aarhus University, Denmark*
[3] *Orbicon, Greenland*
[4] *Lund University, Sweden*
[5] *University of Copenhagen, Denmark*

Very large and extreme variation in grounding resistances (GR) are some of the main challenges in the monitoring of permafrost and active layer processes with Electrical Resistivity Tomography in sedimentary deposits. The unfrozen, wet active layer typically results in low electrode grounding resistances in summer. In winter, however, when the active layer freezes, grounding resistances may increase many orders of magnitude, and hamper the acquisition of meaningfully long time series.

To investigate the factors conditioning the GR, we tested three stainless steel electrode types featuring increased size and surface area:

1. a rod electrode, with diameter 1 cm, length 8 cm and effective surface area: 27 cm^2
2. a square plate electrode, 10*10*0.1 cm (h*w*t), effective surface area: 204 cm^2
3. a wire mesh electrode, 10*10*0.6 cm (h*w*t), effective surface area: 985 cm^2

The electrodes were tested at three different localities in West Greenland: Qeqertarsuaq (69°15'N, 53°30'W, 30 m a.s.l.), Ilulissat (69° 14'N, 51° 3'W, 33 m a.s.l.) and Sisimiut site (66° 56'N, 53° 36'W, approx. 48 m a.s.l.). Each of these sites represents a different surface geology. The soil type at Ilulissat is a silty clay with little organic cover, at Sisimiut it is well drained fine sand likewise with very little organic cover, while at Qeqertarsuaq the surface deposits consists of a coarse sand with high organic content. Sisimiut and Qeqertarsuaq are located in the discontinuous permafrost zone, while Ilulissat has continuous permafrost.

At each site we installed three 10-electrode layouts (electrode separation 30 cm), each featuring a different electrode type. The grounding resistance of each individual electrode was measured using the focus-one protocol. The focus-one protocol, is essentially a two-electrode resistance measurement, where one electrode is connected to one terminal of the instrument, while all the other electrodes of the layout are connected in parallel to the other terminal, thereby effectively minimizing the contribution of their grounding resistances to the total measurement. Measurements were conducted at all three sites summer, fall and winter, to study also the effect of ground temperature.

The measured grounding resistances range from about 600 Ω to 1.2 MΩ (across seasons, electrode types and localities), and the effects of electrode type, locality (surficial geology) and ground temperature all tested statistically significant. Plate electrodes showed 28 to 69 % lower GR than rods during both thawed and frozen ground conditions at all sites. Mesh electrodes improved the GR by 29 to 37 % relative to plate electrodes in winter at the Ilulissat and Qeqertarssuaq sites. The increased effective surface area of the mesh electrodes seems to be an advantage when the electrodes are inserted or buried in fine grained mineral or organic soils with some cohesive properties, where the soil may fill the mesh openings. At the Sisimiut site, the coarser mineral soil results in no advantage of using mesh electrodes. Under thawed conditions, the plate and mesh electrodes did not test statistically different at any of the sites, indicating that the natural variation in soil and burial conditions is larger than the effect of the larger surface area.

An existing 64 electrode monitoring array installed at the Ilulissat site was used to further document the advantage of mesh electrodes over rod electrodes. Operating the monitoring setup, which was originally installed using rod electrodes, had been a challenge due to high grounding resistances in winter, effectively prohibiting the collection of measurements. Replacement of the rod electrodes with mesh electrodes resulted in an immediate reduction of the average GR by 73 % from 1.5±0.9 kΩ to 0.4±0.1 kΩ (thawed conditions). Comparable winter grounding resistances were reduced from 64±32.1 kΩ to 25±11.4 kΩ, and following the replacement, measurements could be collected throughout the season.

We conclude that temperature, electrode shape and properties as well as lithology of the monitored site have significant impact on electrode grounding resistance and array performance, particularly in the cold/dry season. Thus, optimization of the electrode design should be a main consideration when planning a long-term monitoring project. Under the conditions we tested, the use of plate or mesh electrodes instead of rod electrodes were an advantage at all sites and all seasons. Mesh electrodes constitute an improvement only when the soil type allows to take advantage of the larger effective surface area (fine grained mineral or organic soils).